Intel® 5100 Memory Controller Hub Chipset for Communications, Embedded, and Storage Applications

Thermal/Mechanical Design Guide

February 2008

Revision 002US

Order Number: 318676-002US

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Revision History

Date	Revision	Description
February 2008	002	Updated the $TDP_{Max\ config}$ value to 25.7 W in Table 3
November 2007	001	Initial release

Revision Number Descriptions

Revision	Associated Life Cycle Milestone	Release Information
0.0	POP L3 Closure	Initial Documentation - Typically Internal Only
0.1–0.4	When Needed	Project Dependent - Typically Internal Only
0.5	Design Win Phase	First, Required Customer Release
0.6–0.7	When Needed	Project Dependent
0.7	Simulations Complete	Second, Recommended Customer Release
0.8–0.9	When Needed	Project Dependent
1.0	First Silicon Samples	Required Customer Release
1.1–1.4	When Needed	Project Dependent (Recommended)
1.5	Qualification Silicon Samples	Project Dependent
1.6–1.9	When Needed	Project Dependent
NDA - 2.0 Public - XXXXXX-001	First SKU Launch	Required Customer Release - Product Launch
2.1 and up	When Needed	Project Dependent

Note: Rows highlighted in gray are required revisions.

1.0 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and mechanical operating limits and specifications for the Intel® 5100 Memory Controller Hub Chipset (Intel® 5100 MCH Chipset)
- Describe reference thermal solutions that meet the specification of the Intel® 5100 MCH Chipset

Properly designed thermal solutions provide adequate cooling to maintain the Intel® 5100 MCH Chipset die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the Intel® 5100 MCH Chipset die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics is through careful chassis design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

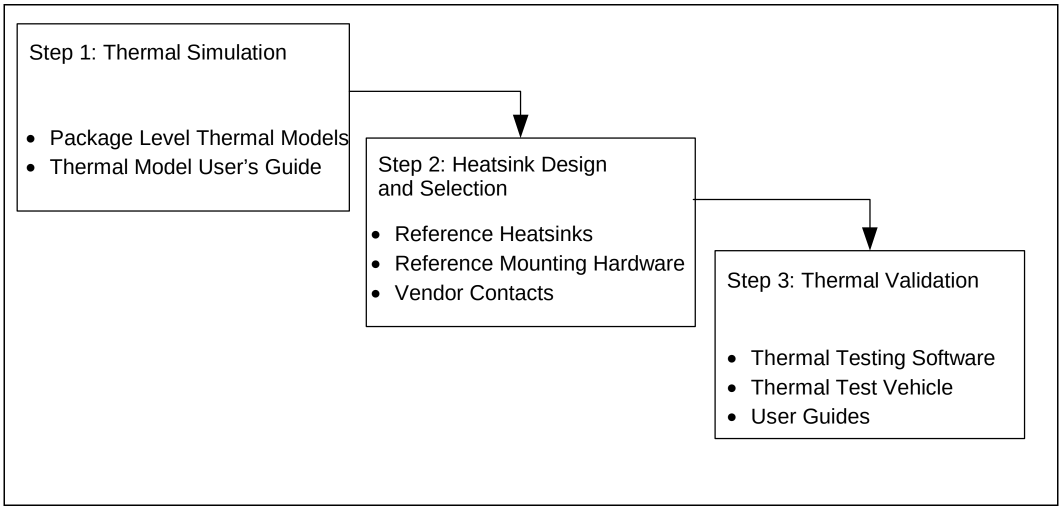
This document addresses thermal design and specifications for the Intel® 5100 MCH Chipset components only. For thermal design information on other chipset components, refer to the respective component datasheet. For the ICH9R, refer to the *Intel® ICH9 – Thermal Design Guidelines*.

Note: Unless otherwise specified, the term “MCH” refers to the Intel® 5100 MCH Chipset.

1.1 Design Flow

To develop a reliable, cost-effective thermal solution, several tools have been provided to the system designer. Figure 1 illustrates the design process implicit to this document and the tools appropriate for each step.

Figure 1. Thermal Design Process



1.2 Definition of Terms

Table 1. Definition of Terms

Term	Definition
FC-BGA	Flip Chip Ball Grid Array. A package type defined by a plastic substrate where a die is mounted using an underfill C4 (Controlled Collapse Chip Connection) attach style. The primary electrical interface is an array of solder balls attached to the substrate opposite the die. ***Note:*** The device arrives at the customer with solder balls attached.
BLT	Bond line thickness. Final settled thickness of the thermal interface material after installation of heatsink.
ICH9	I/O Controller Hub 9
IHS	Integrated Heat Spreader
MCH	Memory controller hub. The chipset component that contains the processor interface, the memory interface, the PCI Express* interface and the ESI interface.
T_{case_max}	Maximum allowed component temperature. This temperature is measured at the geometric center of the top of the package IHS.
T_{case_min}	Minimum allowed component temperature. This temperature is measured at the geometric center of the top of the package IHS.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.
TIM	Thermal Interface Material
Ψ_{CA}	Case-to-ambient thermal characterization parameter. A measure of the thermal solution thermal performance including TIM using the thermal design power. Defined as (T_{CASE} - T_{LA}) / TDP
Ψ_{CS}	Case-to-sink thermal characterization parameter. A measure of the TIM thermal performance using the thermal design power. Defined as (T_{CASE} - T_{LA}) / TDP
Ψ_{SA}	Sink-to-ambient thermal characterization parameter. A measure of heatsink thermal performance using the thermal design power. Defined as (T_{CASE} - T_{LA}) / TDP

1.3 Related Documents

The Intel® Electronic Design Kit (EDK) provides online, real-time collateral updates. The following link takes you to the EDK server and requires you to log into Intel® Business Link (IBL): Quad-Core and Dual-Core Intel® Xeon® Processor 5000 Sequence with Intel® 5100 Memory Controller Hub Chipset for Communications, Embedded, and Storage Applications.

The reader of this specification should also be familiar with material and concepts presented in the documents listed in Table 2.

Table 2. Related Documents

Document	Document Number/URL
82801Ix I/O Controller Hub (ICH9) – External Design Specification (EDS)	Note 1
82801Ix I/O Controller Hub (ICH9) – Specification Update - NDA	Note 1
BGA/OLGA Assembly Development Guide	Note 1
Quad-Core and Dual-Core Intel® Xeon® Processor 5000 Sequence with Intel® 5100 Memory Controller Hub Chipset for Communications, Embedded, and Storage Applications – Platform Design Guide	Note 1
Dual-Core Intel® Xeon® Processor 5100 Series Datasheet	http://www.intel.com/ (313355)
Dual-Core Intel® Xeon® Processor 5100 Series Specification Update	http://www.intel.com/ (313356)
Dual-Core Intel® Xeon® Processor 5100 Series Thermal/ Mechanical Design Guidelines	http://www.intel.com/ (313357)
Intel® 5000 Series Chipset Memory Controller Hub (MCH) Thermal/Mechanical Design Guide	http://www.intel.com/ (313067)
Intel® 5100 Memory Controller Hub Chipset (embedded) – External Design Specification (EDS) Addendum	Note 1
Intel® 5100 Memory Controller Hub Chipset (embedded) – Maximum Power Application	Note 1
Intel® 5100 Memory Controller Hub Chipset Datasheet	http://www.intel.com/ (318378)
Intel® 5100 Memory Controller Hub Chipset Specification Update	http://www.intel.com/ (318385)
Intel® ICH9 – Thermal Design Guidelines	Note 1
Various system thermal design suggestions	http://www.formfactors.org

Notes:
1. Contact your Intel sales representative. Some documents may not be available at this time.

1.4 Thermal Simulation

Intel provides thermal simulation models of the Intel® 5100 MCH Chipset and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated, system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tools Flomerics* FLOTHERM* (version 5.1 or higher) and Fluent* Icepak* (version 4.3.10 or higher). Contact your Intel field sales representative to order the thermal models and user's guides.

2.0 Packaging Technology

The Intel® 5100 MCH Chipset consists of two individual components: the MCH and the ICH9R. The Intel® 5100 MCH Chipset uses a 42.5 mm, 10-layer flip chip ball grid array (FC-BGA) package (see Figure 2, Figure 3, and Figure 4). For information on the ICH9R package, refer to the *Intel® ICH9 – Thermal Design Guidelines*.

Figure 2. MCH Package Dimensions (Top View)

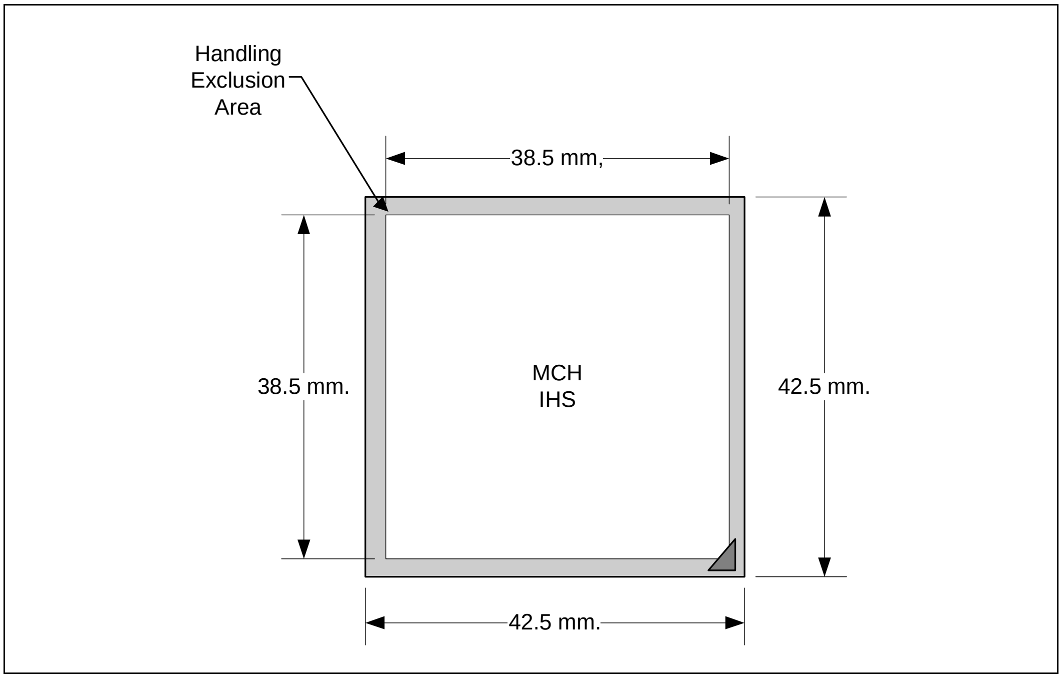
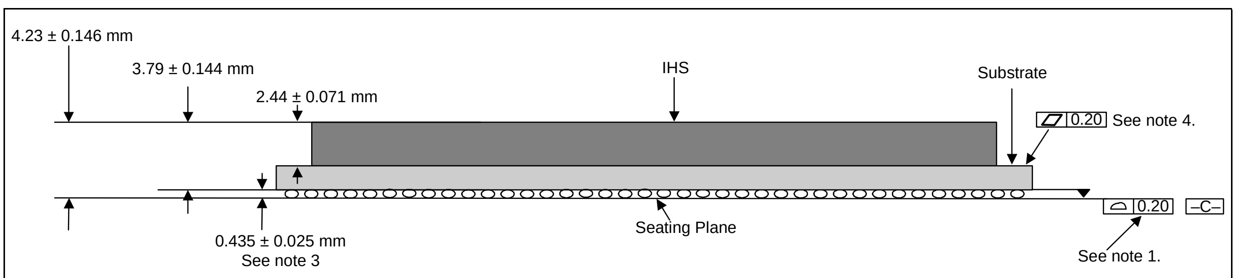
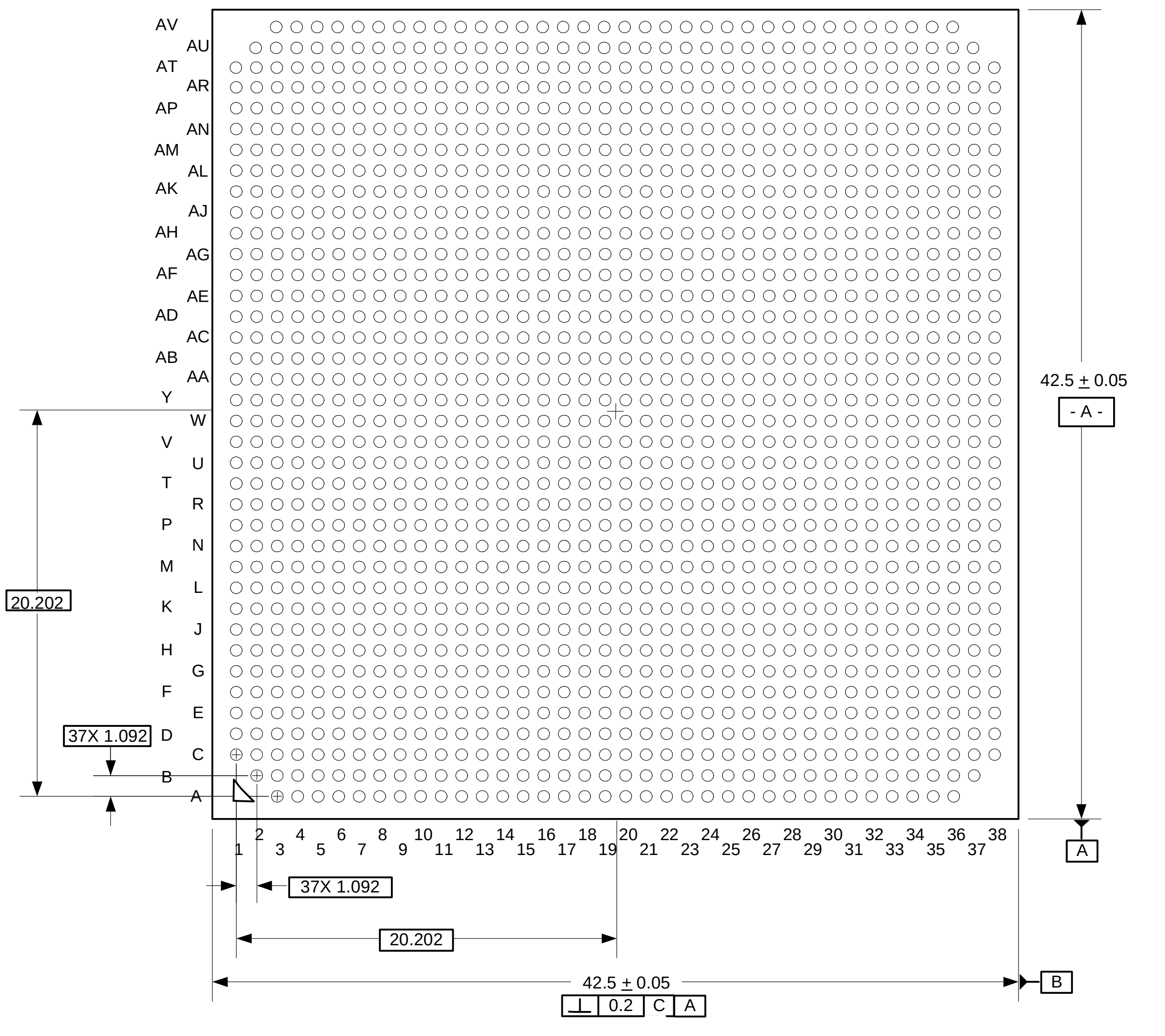


Figure 3. MCH Package Dimensions (Side View)



Notes:
1. Primary datum -C- and seating plan are defined by the spherical crowns of the solder balls (shown before motherboard attach)
2. All dimensions and tolerances conform to ANSI Y14.5M-1994
3. BGA has a pre-SMT height of 0.5mm and post-SMT height of 0.41-0.46mm
4. Shown before motherboard attach; FCBGA has a convex (dome shaped) orientation before reflow and is expected to have a slightly concave (bowl shaped) orientation after reflow

Figure 4. MCH Package Dimensions (Bottom View)



Notes:
1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.

2.1 Package Mechanical Requirements

The Intel® 5100 MCH Chipset package has an integrated heat spreader (IHS) that is capable of sustaining a maximum static normal load of 15 lbf. These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions and/or any other use condition.

Note: The heatsink attach solutions must not include continuous stress to the chipset package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.

Note: These specifications apply to uniform compressive loading in a direction perpendicular to the IHS top surface.

Note: These specifications are based on limited testing for design characterization. Loading limits are for the package only.

3.0 Thermal Specifications

3.1 Thermal Design Power (TDP)

Analysis indicates that real applications are unlikely to cause the MCH component to consume maximum power dissipation for sustained time periods. Therefore, in order to arrive at a more realistic power level for thermal design purposes, Intel characterizes power consumption based on known platform benchmark applications. The resulting power consumption is referred to as the Thermal Design Power (TDP). TDP is the target power level to which the thermal solutions should be designed. TDP is not the maximum power that the chipset can dissipate.

FC-BGA packages have a poor heat transfer capability into the board and have a minimal thermal capability without a thermal solution. Intel recommends that system designers plan for a heatsink when using the Intel® 5100 MCH Chipset.

3.2 Case Temperature

To ensure proper operation and reliability of the Intel® 5100 MCH Chipset, the case temperatures must be at or between the maximum/minimum operating temperature ranges as specified in Table 3. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Section 5.0, “Thermal Metrology” on page 14 for guidelines on accurately measuring package case temperatures.

Table 3. Intel® 5100 Memory Controller Hub Chipset Thermal Specifications

Parameter	Value	Notes
T_{case_max}	105 °C	
T_{case_min}	5 °C	
$TDP_{Max\ config}$	25.7 W	DP FSB 1333, 2 channel DDR2 667, 3 x8 PCI Express*
$TDP_{Typical\ ATCA\ config}$	23.0 W	DP FSB 1067, 2 channel DDR2 533, 3 x8 PCI Express*
$TDP_{Typical\ UP\ config}$	19.5 W	UP FSB 1067, 1 channel DDR2 533, 1 x8 PCI Express*

Note: These specifications are based on preliminary silicon characterization; however, they may be updated as further data becomes available.

4.0 Thermal Solution Requirements

4.1 Characterizing the Thermal Solution Requirement

The idea of a “thermal characterization parameter” Ψ (the Greek letter psi) is a convenient way to characterize the performance needed for the thermal solution and to compare thermal solutions in identical situations (in other words, heating source, local ambient conditions, and so forth). The thermal characterization parameter is calculated using total package power; whereas, actual thermal resistance, θ (theta), is calculated

using actual power dissipated between two points. Measuring actual power dissipated into the heatsink is difficult, because some of the power is dissipated through a heat transfer into the package and board.

The case-to-local ambient thermal characterization parameter (Ψ_{CA}) is used as a measure of the thermal performance of the overall thermal solution. It is defined by Equation 1 and is measured in units of °C/W.

Equation 1. Case-to-local Ambient Thermal Characterization Parameter (Ψ_{CA})

$$\Psi_{CA} = \frac{T_{CASE} - T_{LA}}{TDP}$$

The case-to-local ambient thermal characterization parameter, Ψ_{CA}, is comprised of Ψ_{CS}, the thermal interface material (TIM) thermal characterization parameter, and of Ψ_{SA}, the sink-to-local ambient thermal characterization parameter.

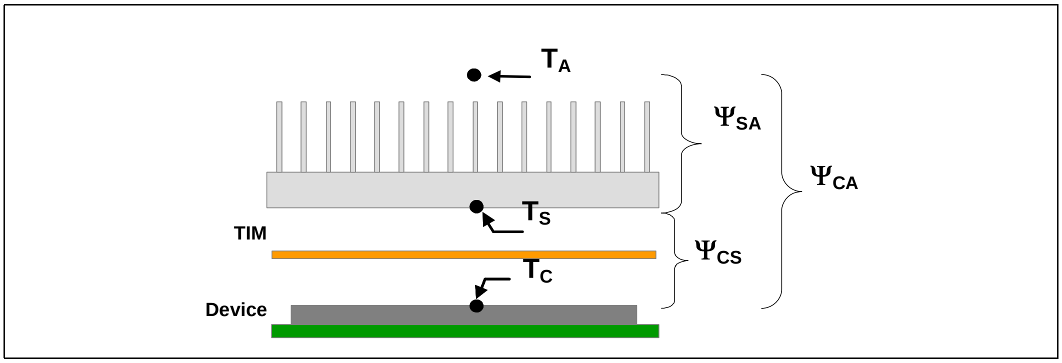
Equation 2. Case-to-local Ambient Thermal Characterization Parameter (Ψ_{CA})

$$\Psi_{CA} = \Psi_{CS} + \Psi_{SA}$$

Ψ_{CS} is strongly dependent on the thermal conductivity and thickness of the TIM between the heatsink and device package.

Ψ_{SA} is a measure of the thermal characterization parameter from the bottom of the heatsink to the local ambient air. Ψ_{SA} is dependent on the heatsink material, thermal conductivity, and geometry. It is also strongly dependent on the air velocity through the fins of the heatsink. Figure 5 illustrates the combination of the different thermal characterization parameters.

Figure 5. Processor Thermal Characterization Parameter Relationships



Example 1. Calculating the Required Thermal Performance

The cooling performance, $\Psi_{CA,}$ is defined using the thermal characterization parameter previously described. The process to determine the required thermal performance to cool the device includes the following.

1. Define a target component temperature T_{CASE} and corresponding TDP.
2. Define a target local ambient temperature, T_{LA}.
3. Use Equation 1 and Equation 2 to determine the required thermal performance needed to cool the device.

The following provides an example of how you might determine the appropriate performance targets.

Assume:

- TDP = 25.0 W and T_{CASE} = 105 °C
- Local processor ambient temperature, T_{LA}, = 60 °C

Then the following could be calculated using Equation 1 for the given chipset configuration.

$$\Psi_{CA} = \frac{T_{CASE} - T_{LA}}{TDP} = \frac{105 - 60}{25} = 1.8°C/W$$

To determine the required heatsink performance, a heatsink solution provider would need to determine Ψ_{CS} performance for the selected TIM and mechanical load configuration. If the heatsink solution were designed to work with a TIM material performing at $\Psi_{CS} \leq 0.20$ °C/W, solving from Equation 2, the performance needed from the heatsink is as follows.

$$\Psi_{SA} = \Psi_{CA} - \Psi_{CS} = 1.8 - 0.20 = 1.6°C/W$$

If the local ambient temperature is relaxed to 45 °C, the same calculation can be carried out to determine the new case-to-ambient thermal resistance.

$$\Psi_{CA} = \frac{T_{CASE} - T_{LA}}{TDP} = \frac{105 - 45}{25} = 2.4°\frac{C}{W}$$

It is evident from the above calculations that a reduction in the local ambient temperature has a significant effect on the case-to-ambient thermal resistance requirement. This effect can contribute to a more reasonable thermal solution including reduced cost, heatsink size, heatsink weight, and a lower system airflow rate.

Table 4 summarizes the thermal budget required to adequately cool the Intel® 5100 MCH Chipset in one configuration using a TDP of 25 W. Further calculations would need to be performed for different TDPs. Because the results are based on air data at sea level, a correction factor would be required to estimate the thermal performance at other altitudes.

Table 4. Required Heatsink Thermal Performance (Ψ_{CA})

Device	Ψ_{CA} (°C/W) at T_{LA} = 45 °C	Ψ_{CA} (°C/W) at T_{LA} = 60 °C
Intel® 5100 MCH Chipset @ 25 W	2.4	1.8

5.0 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the MCH case temperatures. Section 5.1 provides guidelines on how to accurately measure the MCH case temperatures. Section 5.2 contains information on running an application program that will emulate anticipated maximum thermal design power (Figure 6).

5.1 MCH Case Measurement

The Intel® 5100 MCH Chipset cooling performance is determined by measuring the case temperature using a thermocouple. For case temperature measurements, the attached method outlined in this section is recommended for mounting a thermocouple.

Special care is required when measuring the case temperature (T_C) to ensure an accurate temperature measurement. Thermocouples are often used to measure T_C. When measuring the temperature of a surface that is at a different temperature from the surrounding local ambient air, errors may be introduced in the measurements. The measurement errors can be caused by poor thermal contact between the thermocouple junction and the surface of the integrated heat spreader, heat loss by radiation, convection, by conduction through thermocouple leads, or by contact between the thermocouple cement and the heatsink base. To minimize these measurement errors, the approach outlined in the next section is recommended.

Note: The thermocouple attach example shown below is on a different package, but the method and groove dimensions are the same. The thermocouple bead needs to be centered on the IHS.

5.1.1 Supporting Test Equipment

To apply the reference thermocouple attach procedure, it is recommended that you use the equipment (or equivalent) given in Table 5.

Table 5. Thermocouple Attach Support Equipment

Item	Description	Part Number
Measurement and Output		
Microscope	Olympus* light microscope or equivalent	SZ-40
Digital multi-meter	Digital multi-meter for resistance measurement	Not Available
Test Fixture(s)		
Micromanipulator[1]	Micromanipulator set from YOU Ltd. or equivalent mechanical 3D arm with needle (not included) to maintain T_C bead location during the attach process	YOU-3
Miscellaneous Hardware		
Locite* 498* Super Bonder* Instant Adhesive Thermal Cycling Resistant	Super glue with thermal characteristics	49850
Adhesive accelerator	Locite 7452 Tak Pak* accelerator for fast glue curing	18490
Kapton tape	For holding thermocouple in place or equivalent	Not Available
Thermocouple	OMEGA*, 36 gauge, “T” type	5SRTC-TT-36-72
Calibration and Control		
ice point* Cell	OMEGA, stable 0 °C temperature source for calibration and offset	TRCIII
hot point* Cell	OMEGA, temperature source to control and understand meter slope gain	CL950-A-110

Notes:
1. Three axes set consists of (1 ea. U-31CF), (1 ea. UX-6-6), (1 ea. USM6) and (1 ea. UPN-1). More information is available at http://www.narishige.co.jp/you/english/products/set/index.htm.

5.1.2 Thermal Calibration and Controls

It is recommended that full and routine calibration of temperature measurement equipment be performed before attempting to perform a temperature case measurement of the Intel® 5100 MCH Chipset. Intel recommends checking the meter probe set against known standards. This should be done at 0 °C (using an ice bath or other stable temperature source) and at an elevated temperature, around 80 °C (using an appropriate temperature source).

Wire gauge and length also should be considered because some less expensive measurement systems are heavily impacted by impedance. There are numerous resources available throughout the industry to assist with implementation of proper controls for thermal measurements.

Note: It is recommended to follow company standard procedures and wear safety items like glasses for cutting the IHS and gloves for chemical handling.

Note: Ask your Intel field sales representative if you need assistance to groove and/or install a thermocouple according to the reference process.

5.1.3 IHS Groove

Cut a groove in the package IHS according to the drawing given in Figure 6.

Note: The center of the round at the end of the IHS groove should be at the center of the package.

Figure 6. IHS Groove Dimensions

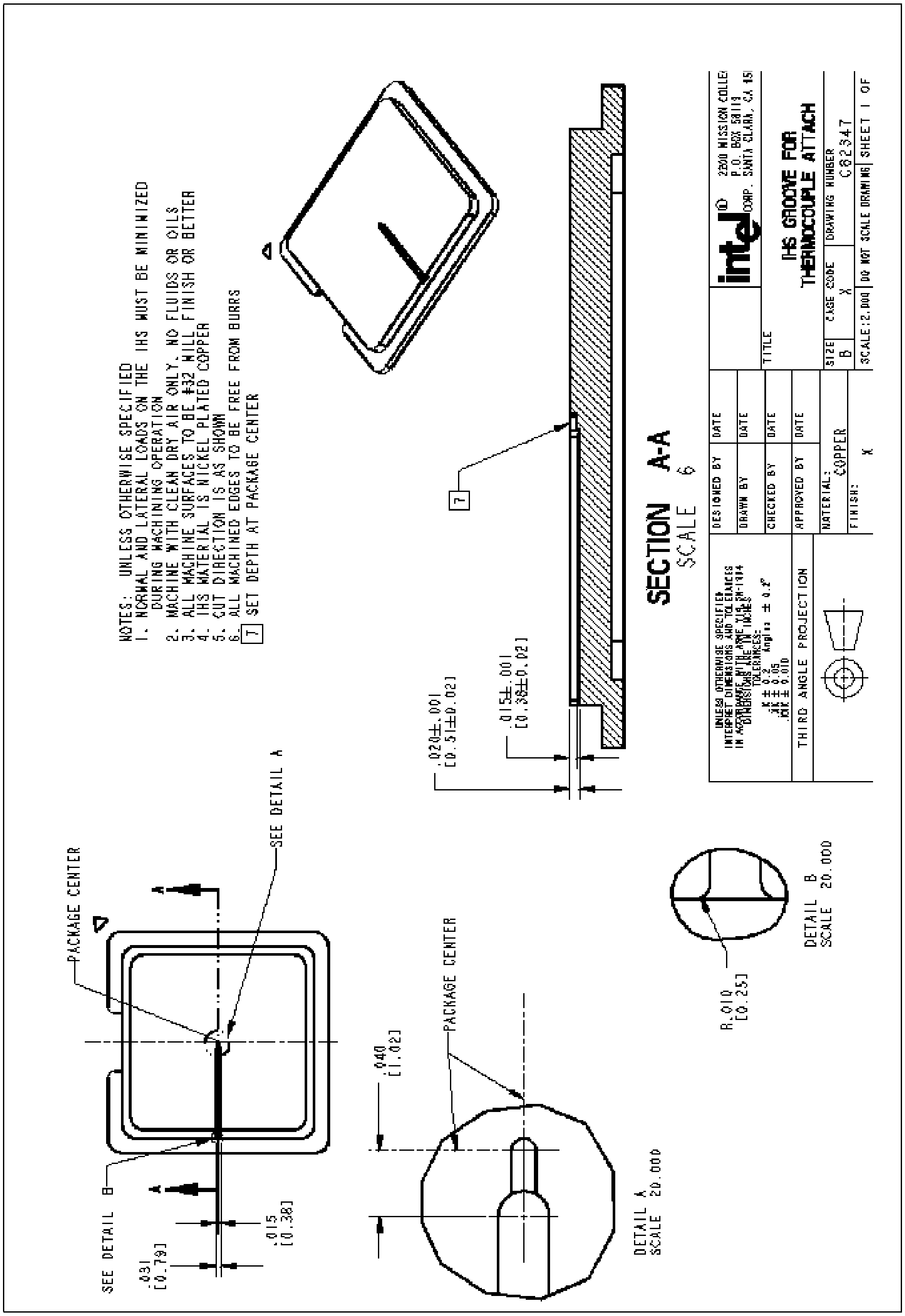
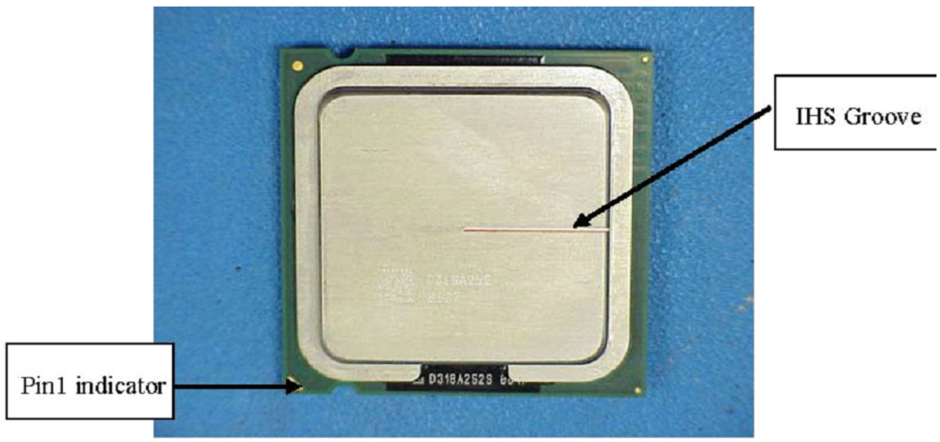


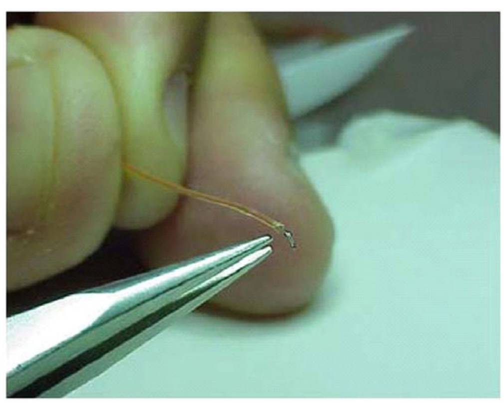
Figure 7. Orientation of Thermocouple Groove Relative to Package Pin



5.1.4 Thermocouple Conditioning and Preparation

1. Use a calibrated thermocouple as specified in Table 5.
2. Measure the thermocouple resistance by holding both wires on one probe and the tip of the thermocouple to the other probe of the DMM (compare to thermocouple resistance specifications).
3. Straighten the wire for about 38 mm (1½") from the bead to place it inside the channel.
4. Bend the tip of the thermocouple to approximately a 45 degree angle by 0.8 mm (0.030") from the tip (Figure 8).

Figure 8. Bending Tip of Thermocouple



5.1.5 Thermocouple Attachment to IHS

Caution: To avoid impact on the thermocouple during the SMT process, reflow must be performed before attaching the thermocouple to the grooved MCH IHS.

1. Clean the thermocouple wire groove with isopropyl alcohol (IPA) and a lint-free cloth removing all residue prior to thermocouple attachment.

2. Place the thermocouple wire inside the groove letting the exposed wire and bead extend about 3.2 mm (0.125") past the end of the groove. Secure it with Kapton tape (Figure 9).
3. Lift the wire at the middle of groove with tweezers and bend the front of the wire to place the thermocouple in the channel ensuring that the tip is in contact with the end of the channel grooved in the IHS (Figure 10 A and B).
4. Place the MCH under the microscope unit (similar to the one used in Figure 13) to continue with the process. It is also recommended to use a fixture to help hold the unit in place for the rest of the attach process.
5. Press the wire down about 6 mm (0.125") from the thermocouple bead using the tweezers. Look in the microscope to perform this task. Place a piece of Kapton tape to hold the wire inside the groove (Figure 12). Refer to Figure 11 for detailed bead placement.
6. Using the micromanipulator, place the needle near the end of groove on top of the thermocouple. Using the X, Y, and Z axes on the arm, place the tip of the needle on top of the thermocouple bead. Press down until the bead is seated at the end of the groove on top of the step (see Figure 11 and Figure 12).
7. Measure resistance from thermocouple end wires (hold both wires to a DMM probe) to the IHS surface. This should be the same value as measured during the thermocouple conditioning. See Section 5.1.4, step 2., and Figure 13.
8. Place a small amount of Locite* 498* Super Bonder* adhesive in the groove where the bead is installed. Using a fine point device, spread the adhesive in the groove around the needle, the thermocouple bead, and the thermocouple wires already installed in the groove during step 5. Be careful not to move the thermocouple bead during this step (Figure 14).

Figure 9. Securing Thermocouple Wires with Kapton Tape Prior to Attach

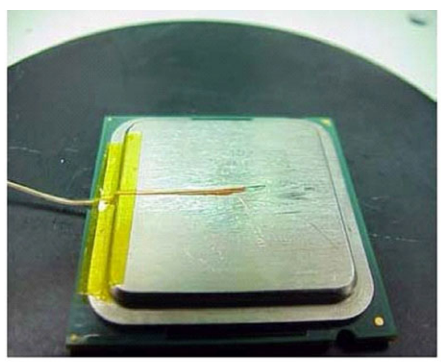


Figure 10. Thermocouple Bead Placement

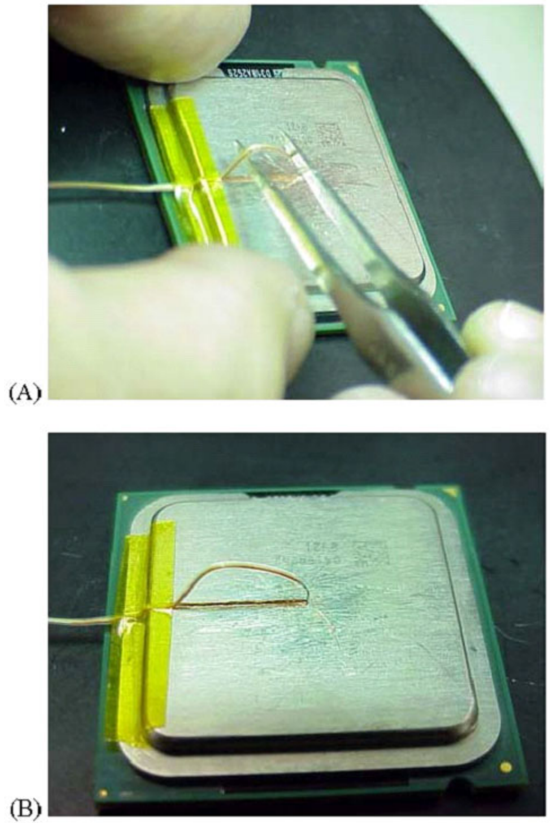


Figure 11. Positioning Bead on Groove

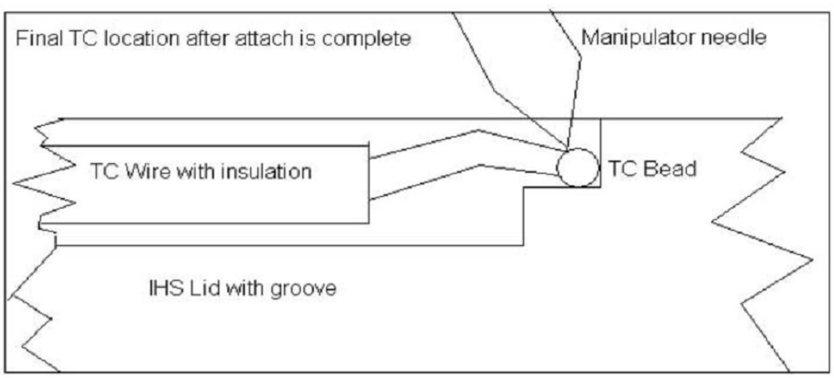


Figure 12. Using 3D Micromanipulator to Secure Bead Location

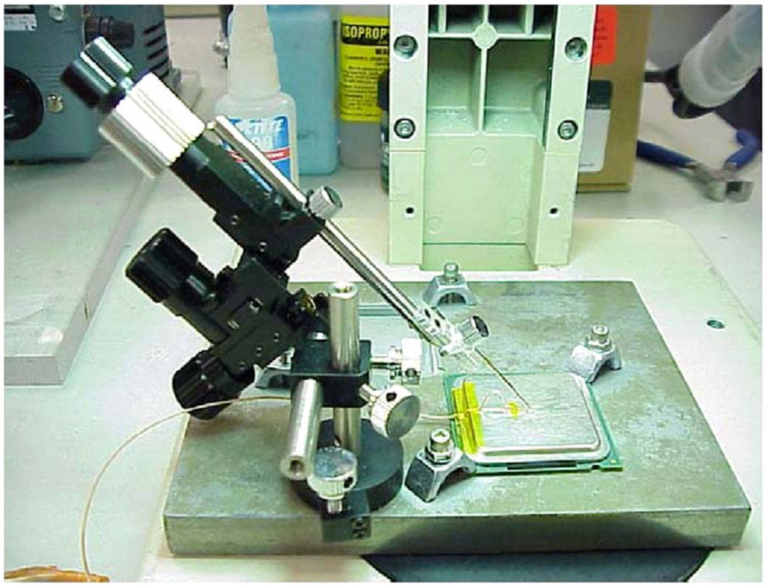


Figure 13. Measuring Resistance between Thermocouple and IHS

Figure 14. Applying Adhesive on Thermocouple Bead

5.1.6 Curing Process

1. Let the thermocouple attach sit in the open air for at least half an hour. Using any curing accelerator like the Locite* 7452 Tak Pak* accelerator for this step is not recommended. Rapid contraction of the adhesive during curing may weaken bead attach on the IHS.
2. Reconfirm electrical connectivity with the DMM before removing the micromanipulator. See Section 5.1.4, step 2., and Figure 13.
3. Remove the 3D arm needle by holding down the MCH unit and lifting the arm.
4. Remove the Kapton tape, and straighten the wire in the groove so that it is flat all the way to the end of the groove (Figure 15).
5. Using a blade, shave excess adhesive above the IHS surface (Figure 16).

Note: Take usual precautions when using open blades.

6. Install new Kapton tape to hold the thermocouple wire down, and fill the rest of the groove with adhesive (Figure 17). Make sure the wire and insulation is entirely within the groove and below the IHS surface.
7. Curing time for the rest of the adhesive in the groove can be reduced using the Locite* 7452 Tak Pak* accelerator.
8. Repeat step 5. to remove any access adhesive to ensure a flat IHS for proper mechanical contact to the heatsink surface.

5.1.7 Thermocouple Wire Management

Figure 15. Thermocouple Wire Management in Groove

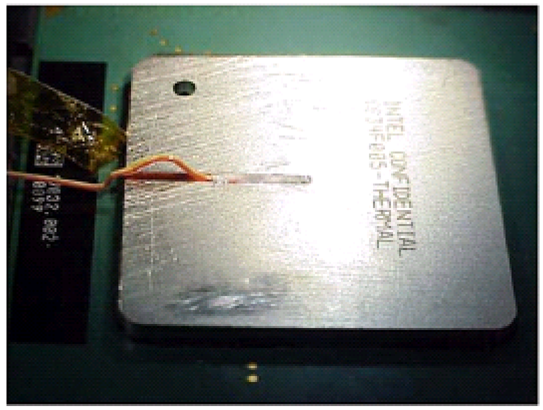
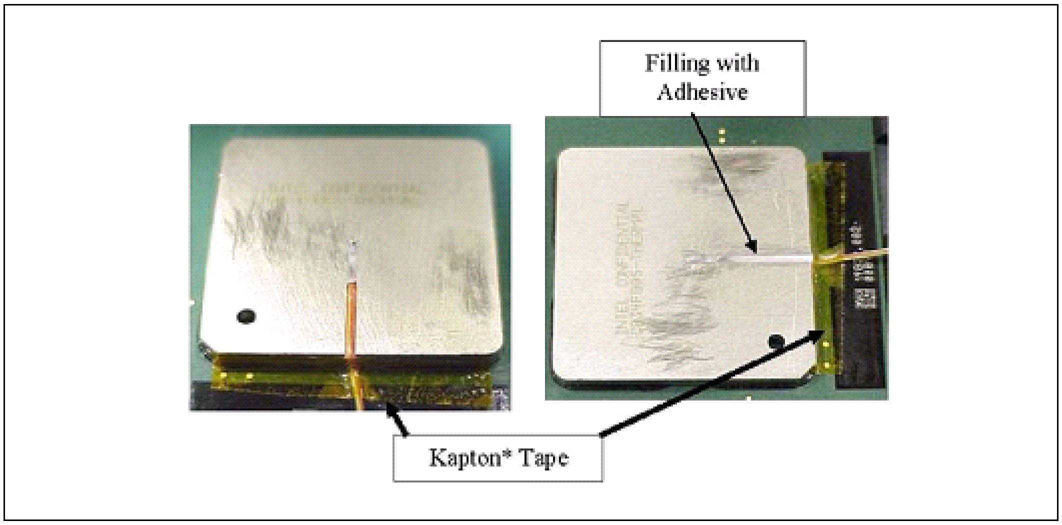


Figure 16. Removing Excess Adhesive from IHS

Figure 17. Filling Groove with Adhesive



Note: Prior to installing the heatsink, be sure that the thermocouple wires remain below the IHS top surface by running a flat blade on top of the IHS, for example.

5.2 Power Simulation Software

Power simulation software now exists for the Intel® 5100 MCH Chipset. The power simulation software is a utility designed to dissipate the thermal design power on a Intel® 5100 MCH Chipset when used in conjunction with the Dual-Core Intel® Xeon® processor 5X00 series. The combination of the above mentioned processor(s) and the higher bandwidth capability of the Intel® 5100 MCH Chipset enables higher levels of system performance. To assess the thermal performance of the MCH chipset thermal solution under “worst-case realistic application” conditions, Intel developed a software utility that operates the chipset at near worst-case thermal power dissipation.

The power simulation software developed should only be used to test thermal solutions at or near the thermal design power. Real world applications may exceed the thermal design power limit for transient time periods. For power supply current requirements under these transient conditions, please refer to each component’s datasheet for the ICC (Max Power Supply Current) specification. Contact your Intel field sales representative to order the power simulation software: *Intel® 5100 Memory Controller Hub Chipset (embedded) – Maximum Power Application*.

6.0 Reference Thermal Solution

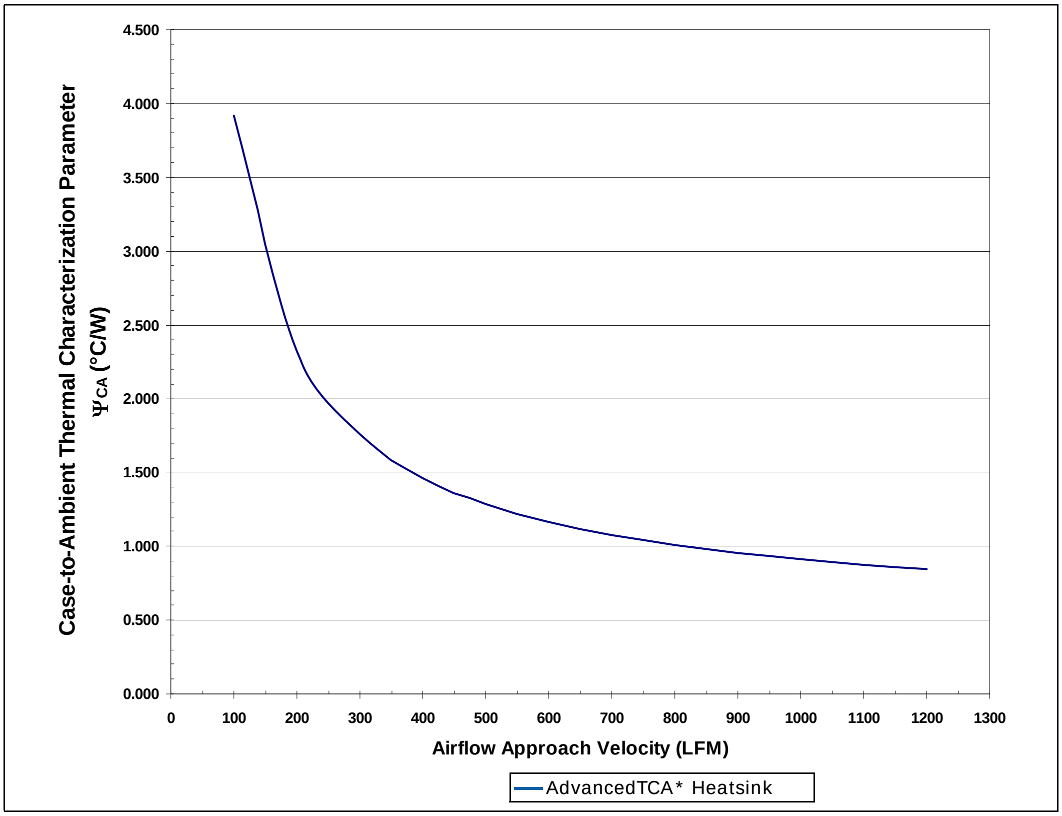
Intel has developed one reference thermal solution to meet the cooling needs of the Intel® 5100 MCH Chipset under the embedded operating environments and specifications defined in this document. This chapter describes the overall requirements for the torsional clip heatsink reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions depending on your specific system local-ambient operating conditions. For information on the ICH9R, refer to the thermal specification in the *Intel® ICH9 – Thermal Design Guidelines*.

The Intel® 5100 MCH Chipset has a lower TDP than the Intel® 5000 Series Chipset and a similar package size. Due to this, any thermal solutions for the Intel® 5000 Series Chipset should be reusable for the Intel® 5100 MCH Chipset including the Intel reference solutions. The system designer still needs to verify that the entire thermal solution will meet the component temperature specifications and TDP in the intended system.

6.1 Thermal Performance

The AdvancedTCA* reference heatsink should be made from aluminum to achieve the necessary thermal performance. Depending on the boundary conditions, the reference heatsink can meet the thermal performance needed to cool the Intel® 5100 MCH Chipset in the AdvancedTCA* form factor. The heatsink performance versus airflow velocity is shown in Figure 18. The heatsink may be used in other form factors that can provide the required amount of airflow to meet the components thermal specifications.

Figure 18. Torsional Clip Heatsink Measured Thermal Performance versus Approach Velocity

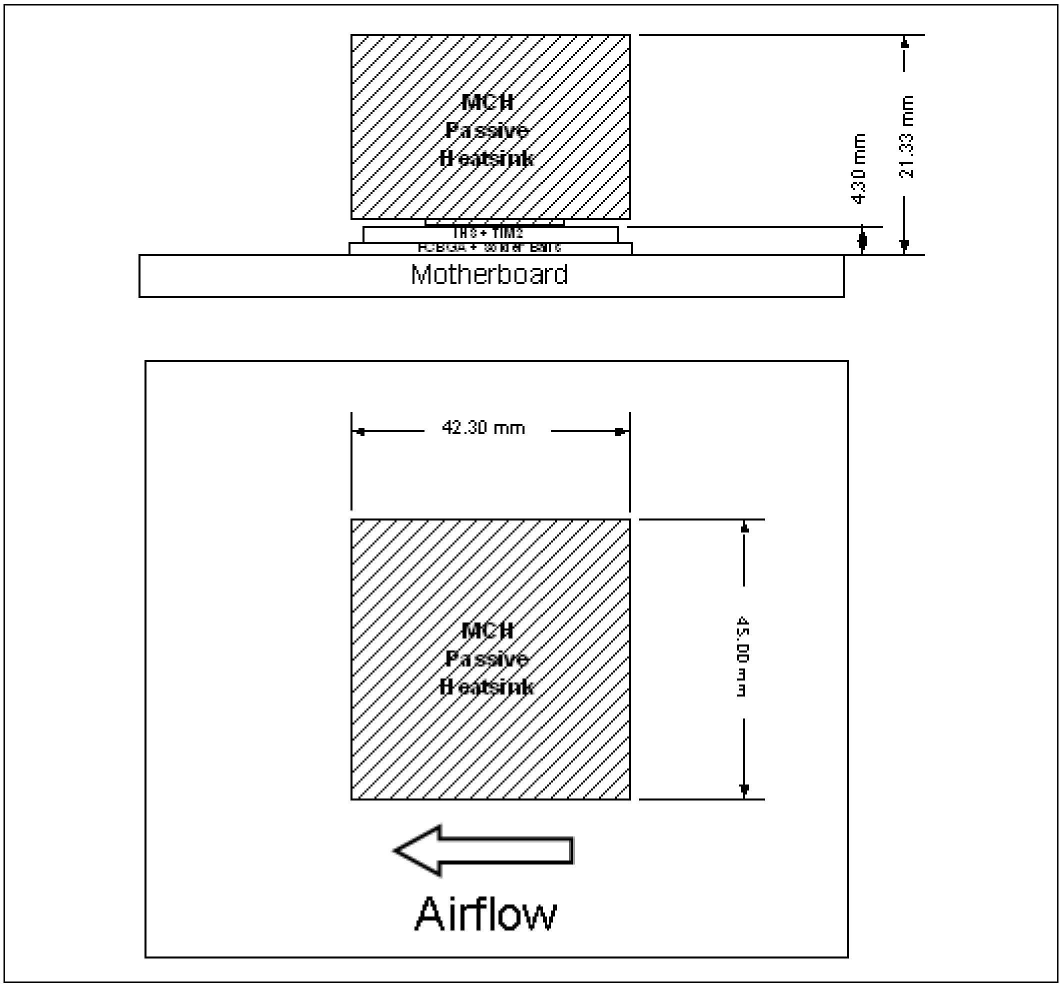


6.2 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the Intel® 5100 MCH Chipset thermal solution are shown in Figure 19.

When using heatsinks that extend beyond the MCH chipset reference heatsink envelope shown in Figure 19, any motherboard components placed between the heatsink and motherboard cannot exceed 2 mm (0.07") in height.

Figure 19. AdvancedTCA* Torsional Clip Heatsink Volumetric Envelope for MCH Heatsink



6.3 Board-level Components Keepout Dimensions

The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 25. This reference thermal solution has the same hole patterns as that of the Intel® E7500 Series Chipset and Intel® 5000 Series Chipset.

6.4 Torsional Clip Heatsink Thermal Solution Assembly

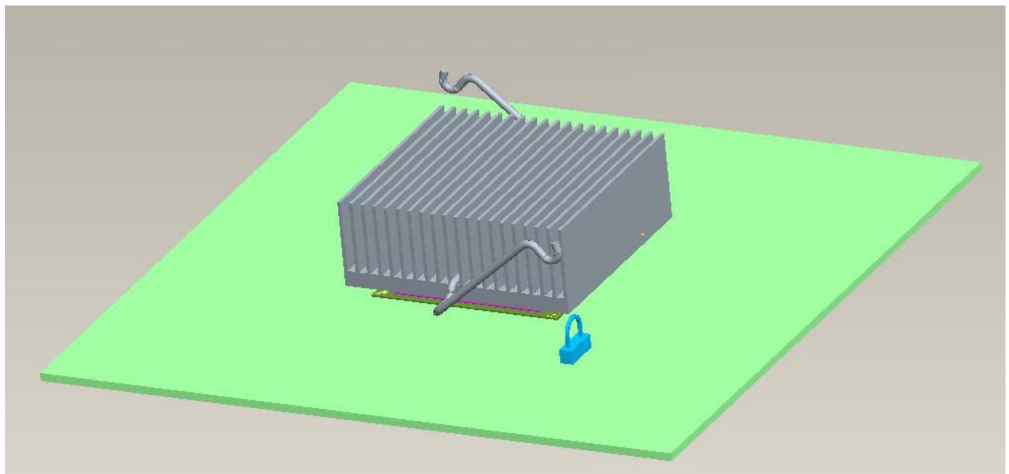
The reference thermal solution for the MCH is a passive extruded heatsink with a thermal interface. It is attached using a clip with each end hooked through an anchor soldered to the board. Figure 20 shows the reference thermal solution assembly and associated components. The torsional clip and the clip retention anchor are the same as the ones used on the Intel® E7500 Series Chipset reference thermal solution.

Full mechanical drawings of the thermal solution assembly and the heatsink clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

6.4.1 Heatsink Orientation

Because this solution is based on a unidirectional heatsink, the mean airflow direction must be aligned with the direction of the heatsink fins.

Figure 20. Torsional Clip Heatsink Assembly



6.4.2 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the MCH. Appendix A lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. A full mechanical drawing of this heatsink is provided in Appendix B.

6.4.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.4.4 Thermal Interface Material

A thermal interface material (TIM) provides improved conductivity between the IHS and heatsink. The reference thermal solution uses Honeywell* PCM45F, 0.25 mm (0.010") thick, 25 mm x 25 mm (0.984" x 0.984") squared.

Note: Unflowed or “dry” Honeywell* PCM45F has a material thickness of 0.010". The flowed or “wet” Honeywell* PCM45F has a material thickness of ~0.003" after it reaches its phase change temperature.

6.4.4.1 Effect of Pressure on TIM Performance

As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the bond line thickness (BLT). BLT is the final settled thickness of the thermal interface material after installation of heatsink. The effect of pressure on the thermal resistance of the Honeywell* PCM45F TIM is shown in Table 6.

Intel provides both End of Line and End of Life TIM thermal resistance values of Honeywell* PCM45F. End of Line and End of Life TIM thermal resistance values are obtained through measurement on a Test Vehicle similar to the Intel® 5000 Series

Chipset's physical attributes using an extruded aluminum heatsink. The End of Line value represents the TIM performance post heatsink assembly, while the End of Life value is the predicted TIM performance when the product and TIM reaches the end of its life. The heatsink clip provides enough pressure for the TIM to achieve an End of Line thermal resistance of 0.345 (°C × inches^2)/W and End of Life thermal resistance of 0.459 (°C × inches^2)/W.

Table 6. Honeywell* PCM45F TIM Performance as Function of Attach Pressure

Pressure (psi)	Thermal Resistance (°C × inches^2) / W	
	End of Line	End of Life
2.18	0.319	0.551
4.35	0.345	0.459

6.4.5 Heatsink Clip

The reference solution uses a wire clip with hooked ends. The hooks attach to wire anchors to fasten the clip to the board. See Appendix B for a mechanical drawing of the clip.

6.4.6 Clip Retention Anchors

For the Intel® 5100 MCH Chipset-based platforms that have very limited board space, a clip retention anchor has been developed to minimize the impact of clip retention on the board. It is based on a standard three-pin jumper and is soldered to the board like any common through-hole header. A new anchor design is available with 45 degree angle bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information.

6.5 Reliability Guidelines

Each motherboard, heatsink, and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in Table 7.

Table 7. Reliability Guidelines

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	50 g, board level, 11 ms, three shocks/axis	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 minutes/axis, 50 Hz to 2000 Hz	Visual Check and Electrical Functional Test
Temperature Life	85 °C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours	Visual Check
Thermal Cycling	-5 °C to +70 °C, 500 cycles	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours	Visual Check

Notes:
1. It is recommended that the above tests be performed on a sample size of at least 12 assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.

7.0 Reliability Guidelines

Each motherboard, heatsink, and attach combination may vary the mechanical loading of the component. The user should carefully evaluate the reliability of the completed assembly prior to use in high volume. Some general recommendations are shown in Table 8.

Table 8. Reliability Requirements

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	50 g, board level, 11 ms, three shocks/axis	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 minutes/axis, 50 Hz to 2000 Hz	Visual Check and Electrical Functional Test
Temperature Life	85 °C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours	Visual Check
Thermal Cycling	-5 °C to +70 °C, 500 cycles	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours	Visual Check

Notes:
1. The above tests should be performed on a sample size of at least 12 assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.

Appendix A Thermal Solution Component Suppliers

Table 9. MCH Torsional Clip Heatsink Thermal Solution

<table>
<tr><th>Part</th><th>Intel Part Number</th><th>Supplier (Part Number)</th><th>Contact Information</th></tr>
<tr><td>AdvancedTCA* heatsink</td><td>D96852-001</td><td>Cooler Master* (TBD)</td><td>Wendy Lin (USA)
510-770-8566 x211
wendy@coolermaster.com</td></tr>
<tr><td>Thermal interface</td><td>C34795-001</td><td>Honeywell* (PCM45F)</td><td>Scott Miller
509-252-2206
scott.miller4@honeywell.com
Paula Knoll
858-279-2956
paula_knoll@honeywell.com</td></tr>
<tr><td rowspan="2">Heatsink attach clip</td><td rowspan="2">D10234-001</td><td>CCI*/ACK</td><td>Harry Lin (USA)
714-739-5797
hlinack@aol.com
Monica Chih (Taiwan)
866-2-29952666, x1131
monica_chih@ccic.com.tw</td></tr>
<tr><td>Foxconn*</td><td>Bob Hall (USA)
503-693-3509, x235
bhall@foxconn.com</td></tr>
<tr><td>Solder-down anchor</td><td>A13494-005</td><td>Foxconn (HB96030-DW)</td><td>Julia Jiang (USA)
408-919-6178
juliaj@foxconn.com</td></tr>
</table>

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify the time of component availability.

Appendix B Mechanical Drawings

Table 10 lists the mechanical drawings included in this appendix.

Table 10. Mechanical Drawing List

Drawing Description	Figure Number
MCH heatsink assembly	Figure 21
MCH heatsink	Figure 22
TIM2	Figure 23
MCH torsional clip	Figure 24
AdvancedTCA* component keepout zone	Figure 25

Figure 21. MCH Heatsink Assembly Drawing

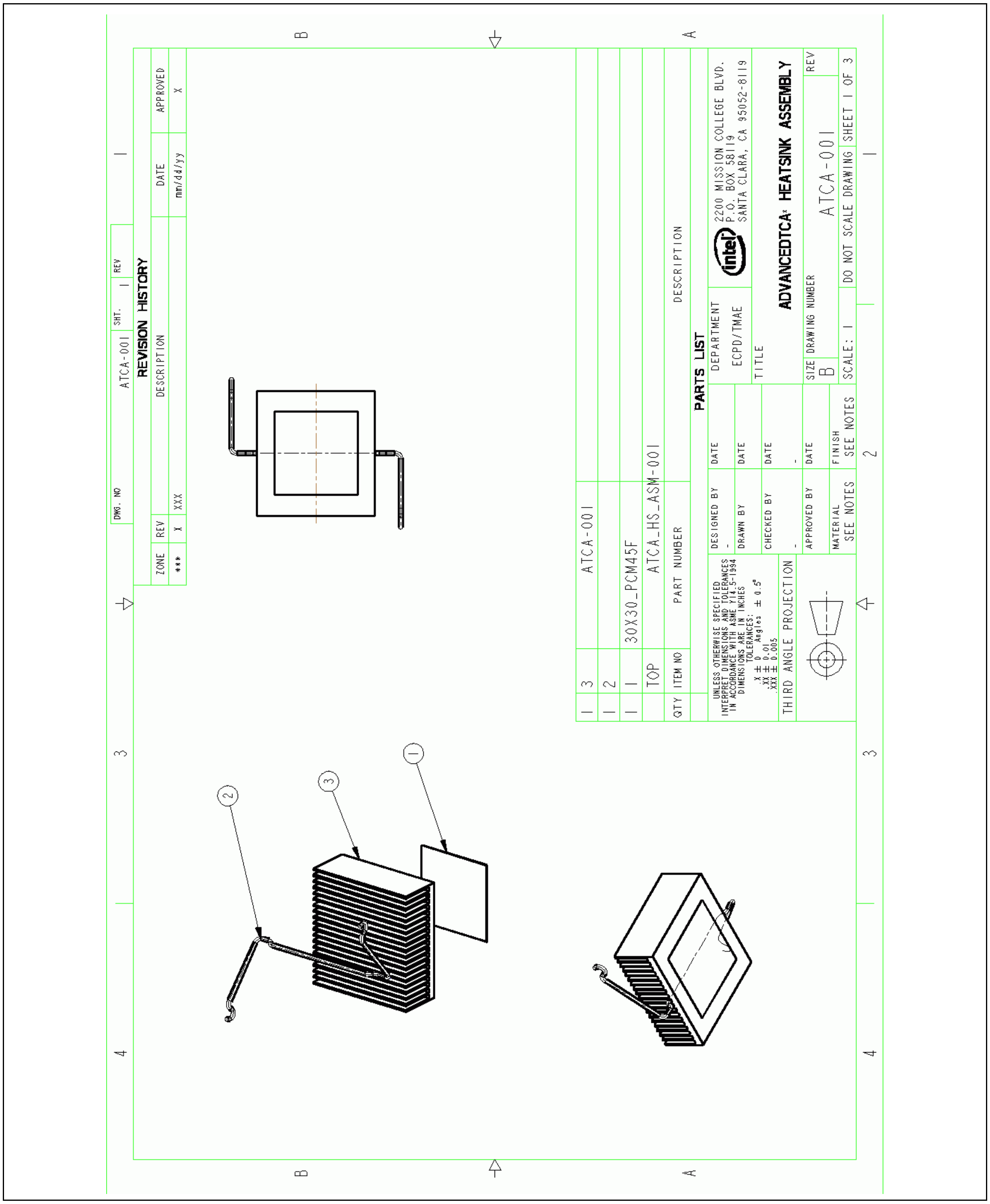


Figure 22. MCH Heatsink Drawing

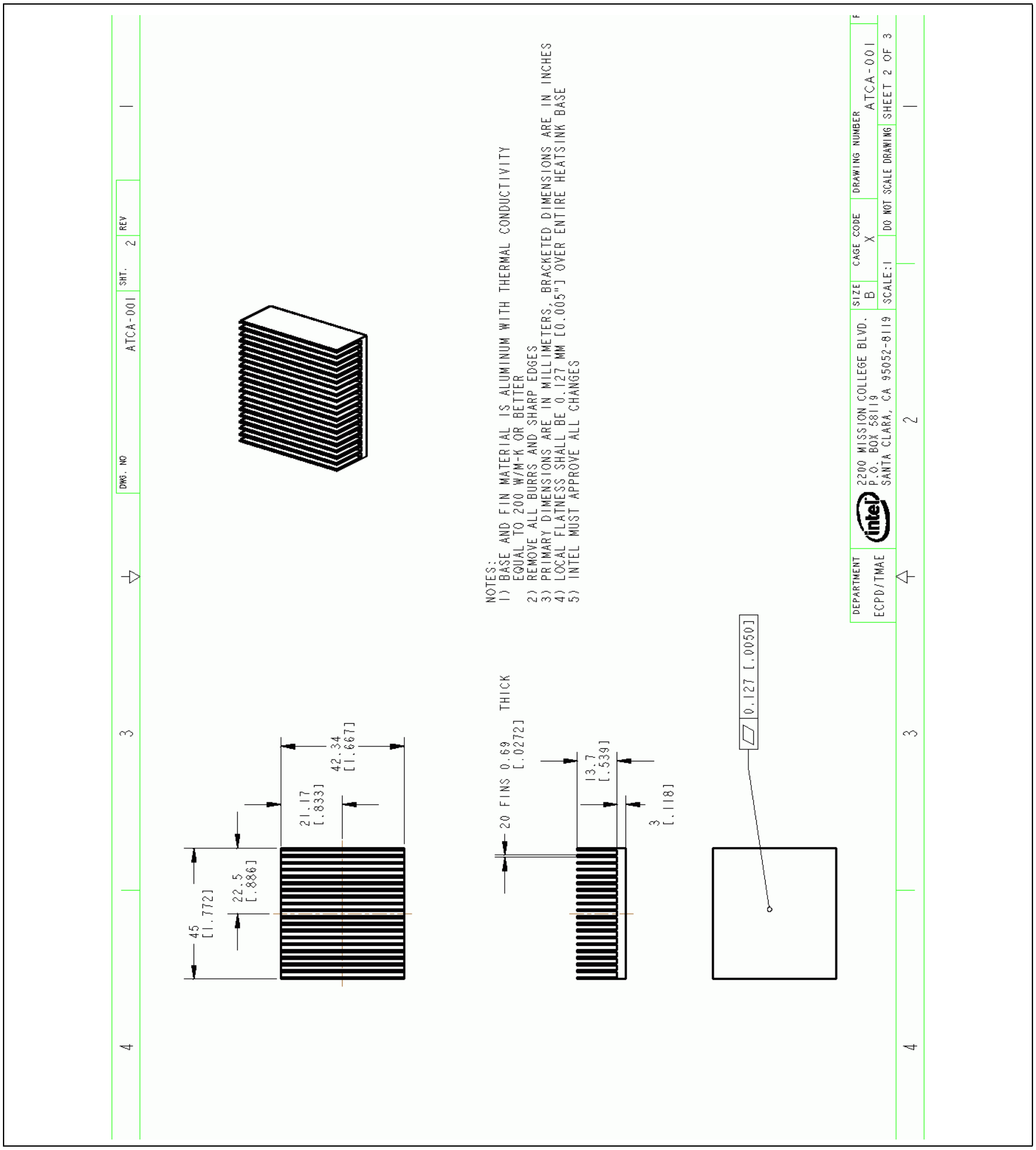


Figure 23. TIM2 Drawing

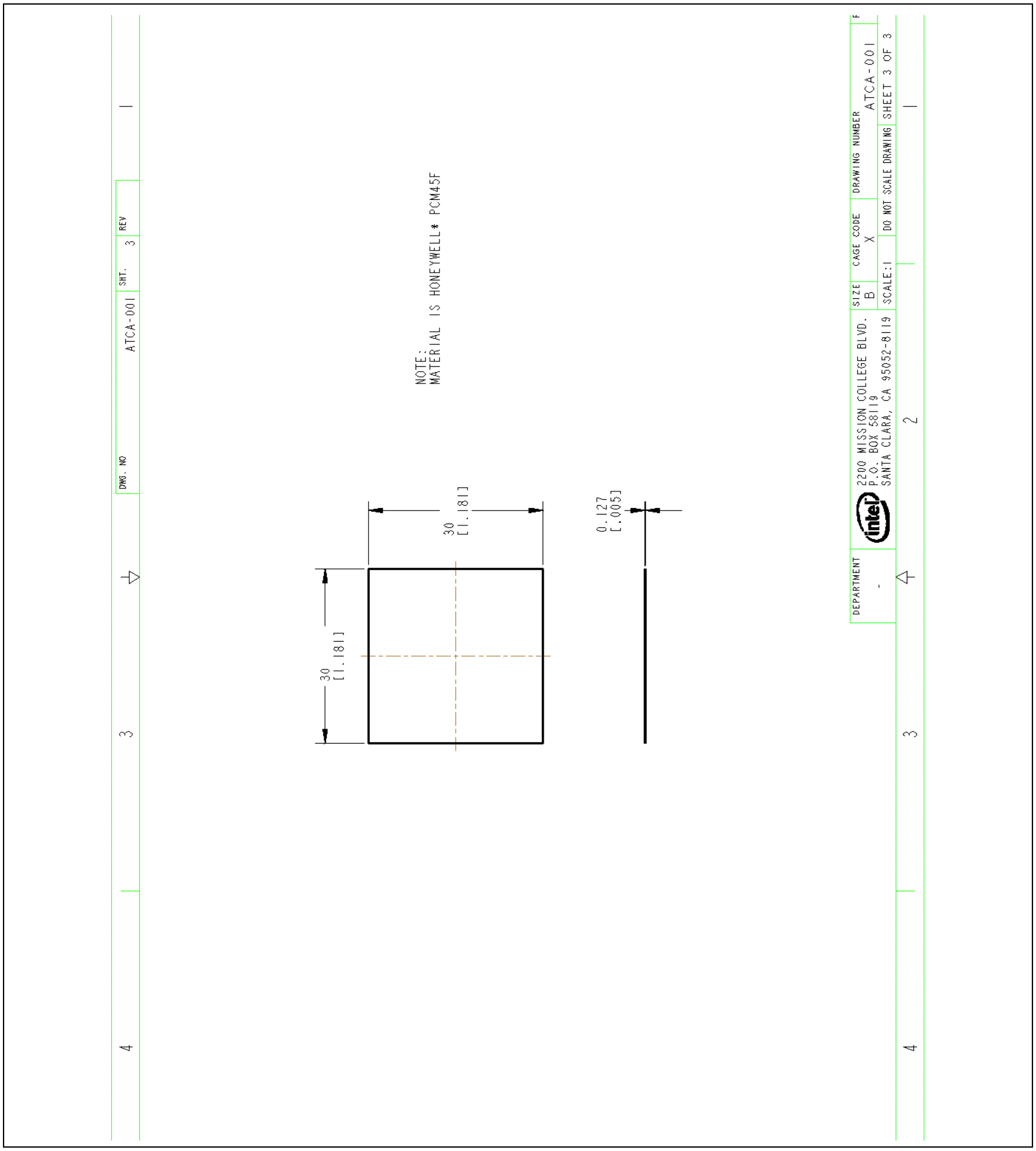


Figure 24. Torsional Clip Heatsink Clip Drawing

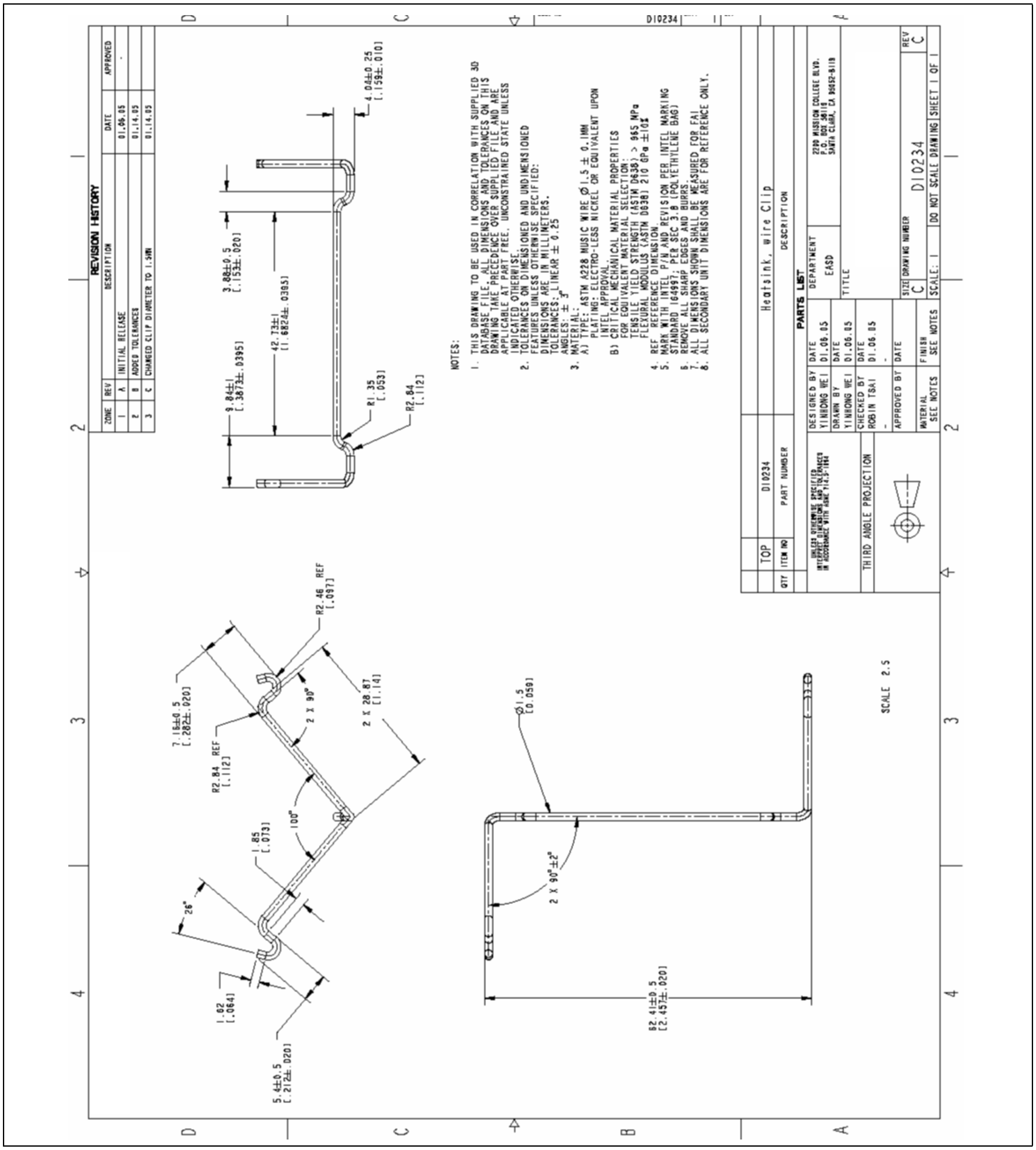


Figure 25. AdvancedTCA* Component Keepout Zone